FIG. **9** is a table illustrating a first set of data to be used in one embodiment of the present invention;

FIG. **10** is a table illustrating a second set of data to be used in another embodiment of the present invention; and

FIG. **11** shows a device for providing tactile sensations according to one embodiment of the present invention.

DETAILED DESCRIPTION

The present invention includes methods and systems for providing tactile sensations. One embodiment includes methods and systems for providing tactile sensations to input devices, both mechanical and non-mechanical (for example soft-keys that are computer generated and displayed on a screen). Embodiments of the present invention can be utilized in wide variety of electronic devices including telephones, mobile telephones, remote controls, gamepads, joystick handles, automotive controls (radios, Compact Disc (CD) players, automobile functions, etc.), consumer electronics devices, Personal Digital Assistants (PDAs), personal computers, laptop computers, portable gaming devices, pagers, I-pagers, audio equipment, televisions, security or alarm systems, Automated Teller Machines (ATM), calculators, home appliances, and white goods.

FIG. **1** shows one embodiment of the present invention. The apparatus **1** shown in FIG. **1** includes an input device **2** having multiple positions for communicating a plurality of input signals. The input device **2** can be any device capable of transmitting an input signal. In the embodiment shown, the input device **2** is a rocker-type switch. The rocker switch **2** shown can pivot or rock between two positions in which the rocker switch contacts and activates one of two rubber switches **3** containing conductive pads. The use of rubber switches **3** provides the advantage of allowing the user to still feel a substantial vibration or force through the input device **2** when the user had fully depressed the switch. Suitable rubber switches are available and known in the art. In other embodiments, the input device may include an analog switch, a force sending resistor, a strain gauge based sensor, a capacitative touch switch, a scroll wheel, a mini-joystick, a touchpad, a touch screen, a 3-way switch, a 4-way switch, a 5-way switch, or other input device. Each position of the input device **2** corresponds to one of the input signals.

The input device **2** and rubber switches **3** are mounted on a Printed Circuit Board (PCB) **4** in the embodiment shown to facilitate electrical communication between the input device **2** and an electronic device (not shown). The PCB **4** can be custom shaped according to the device into which the apparatus **1** is placed. The PCB **4** also provides for secure mounting within the device by including, for example, a plurality of holes **5** to accept fasteners for securing to the electronic device. In another embodiment, the input device **2** can be directly connected or mounted in the electronic device.

The apparatus **1** shown in FIG. **1** also includes a vibrotactile actuator **6** in communication with the input device **2**. Preferably, the actuator **6** is configured to output a plurality of distinct tactile feedback sensations to the input device **2**. Suitable tactile sensations include vibrations, for example, jolts and textures, and a plurality of distinct tactile sensations can be created by varying the frequency, amplitude and waveform output by the actuator **6**. The actuator **6** is selected to deliver the desired tactile sensations to the input device **2** The actuator **6** shown in FIG. **1** is a voice coil actuator. Other suitable actuators include, for example, piezo-electric actuators, eccentric mass actuators, moving magnet actuators, and friction brakes in contact with metal shafts. In addition, the actuator can include a flexure, for example an arrangement of flexible material, coupled to the rotating shaft of a DC motor or step motor to transform the rotation of the motor shaft into vibrations or other haptic sensations. Various arrangements of a flexure coupled to a motor may be used as an actuator. For example, U.S. patent application Ser. No. 09/585,741, filed Jun. 2, 2000, illustrates suitable arrangements of flexures and motors for use as an actuator in embodiments of the present invention. The entire disclosure of the application Ser. No. 09/585,741 is incorporated herein by reference. Tactile sensations can also be delivered to the input device **2** from a speaker included with an electronic device into which the apparatus is placed, for example the speaker in a mobile telephone or in a personal computer.

Although the embodiment shown in FIG. **1** includes one input device **2** and one actuator **6**, other embodiments include a plurality of input devices, all in communication with a single actuator. Alternatively, an embodiment can include a plurality of actuators each in communication with at least one input device. Various arrangements of actuators in combination with input devices are suitable for use in the present invention. For example, U.S. patent application Ser. No. 09/263,263, filed Jul. 26, 2001, published on Mar. 21, 2002, as U.S. Patent Pub. No. US2002/0033795 illustrates actuators in combination with input devices that may be used in embodiments of the present invention. The entire disclosure of application Ser. No. 09/263,263, Pub. No. 2002/0033795 is incorporated herein by reference.

As mentioned, the actuator **6** is in communication with the input device **2**. In the embodiment shown in FIG. **1**, the actuator **6** is in communication with the input device **2** through a cantilevered beam or lever arms **7** attached to the pivoting rocker, amplifying the effective forces of the actuator **6** felt by the user. The tactile sensations generated by the actuator **6** propagate through the lever arm **7** to the input device **2**. Suitable materials for the lever arm **7** are capable of transmitting the tactile sensations and can be, for example, metal. The lever arm **7** shown includes one or more bends **8** to fit within the electronic device in which the apparatus **1** is disposed. Different shapes of bends may be used to fit within the electronic device. In another embodiment, the actuator **6** is mounted directly to the input device **2** or to any component of the input device. Alternatively, the actuator **6** is mounted to the PCB **4** to which the input device is attached, communicating tactile sensations to the input device through the PCB. In another embodiment, the actuator is an existing eccentric mass motor as is used, for example, as a vibrating ringer in a pager or mobile telephone.

The vibrotactile actuator **6** can also be mounted to a portion of the case or housing of the electronic device in which the apparatus **1** is disposed, communicating the tactile sensations to the entire electronic device. In one embodiment, two actuators can be incorporated in the case or back of an electronic device, for example the case of a mobile phone in an area that contacts the user's hand. This arrangement effectively doubles the amplitude of the tactile sensation, and the user's fingers do not tend to attenuate the tactile sensation.

The apparatus **1** also includes a controller **9** in communication with the input device **2** to receive the input signals therefrom. The controller **9** can also receive additional information from the input device **2** including the position of the input device **2** and the amount of pressure applied to the input device **2**. In one embodiment, the input signal includes information related to the amount of pressure applied to the input device **2**, information related to the position of the input device **2**, or a combination of information about pressure and position. In addition to being in communication with the input device **2**, the controller **9** is in communication with the actua-